



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US98/13531 (22) International Filing Date: 29 June 1998 (29.06.98) (30) Priority Data: 60/051,804 7 July 1997 (07.07.97) US 09/105,513 26 June 1998 (26.06.98) US (71) Applicant: LIBBEY-OWENS-FORD CO. [US/US]; 811 Madison Avenue, Toledo, OH 43697 (US). (72) Inventors: McCURDY, Richard, J.; 2456 Barrington Drive, Toledo, OH 43606 (US). SOUBEYRAND, Michel, J.; 7935 North Shoreline Drive, Holland, OH 43528 (US). STRICKLER, David, A.; 2339 Barrington Drive, Toledo, OH 43606 (US). (74) Agent: SCHURR, Donald, A.; Marshall & Melhorn, 8th floor, Four Seagate, Toledo, OH 43604 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: NEUTRAL GREY ABSORBING FILM (57) Abstract <p>A color neutral absorbing film applied as a coating on a glass substrate. The film is an antimony/tin oxide alloy coating containing at least about five atomic percent antimony. The coating is suitable for use in antireflective coatings containing other metal oxides or mixed metal oxides to achieve a coated glass article having a visible light transmittance of 30 % or greater and a reflectance of less than 5 %.</p>		

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TITLE

NEUTRAL GREY ABSORBING FILM

BACKGROUND OF THE INVENTION

5 This invention relates to a neutral absorbing film
suitable for use as a coating on a glass substrate. More
particularly, this invention relates to a non-conductive
and energy absorbing coating of an antimony/tin oxide
10 alloy. Even more particularly, this invention is directed
to an antimony/tin oxide alloy coating applied onto a glass
substrate to impart energy absorption and anti-reflective
properties to the coated glass article.

Coatings on glass are commonly utilized to provide
specific energy attenuation and light transmittance
15 properties. Additionally, coatings are designed to reduce
reflections from interfaces between individual coating
layers and the glass when a plurality of coatings are
applied onto a glass substrate. The coated articles are
often utilized singularly, or in combination with other
20 coated articles, to form a glazing.

The attributes of a coated glass substrate are
dependent upon the specific coatings applied to the glass
substrate. The coating compositions and thicknesses impart
energy absorption and light transmittance properties within
25 the coated article while also affecting the spectral
properties. Desired attributes may be obtainable by
adjusting the compositions or thicknesses of the coating
layer or layers. However, adjustments to enhance a
specific property can adversely impact other transmittance
30 or spectral properties of the coated glass article.
Obtaining desired spectral properties is often difficult

when trying to combine specific energy absorption and light transmittance properties in a coated glass article.

Anti-reflective coatings on glass are utilized to reduce the surface reflection of optical components and to reduce the reflectance of an interface between optical media with different refractive indices. The reduction of visible reflection is achieved by the principle of optical interference. When light impinges on the air-film, film-film, and film-glass interfaces, a portion of the beam is reflected at each interface. By proper choice of thin film materials and thicknesses, the individual reflected light beams can destructively interfere thereby reducing the observed visual reflectance.

The utilization of a coating having absorption properties enables further reduction in reflection by absorbing the light as it travels through the high index absorbing film thereby reducing the light energy incident on the back glass interface and glass-film interface. The absorption of visible light results in the reduction of visible light transmitted through the glass. Generally, absorbing films are strongly colored and therefore do not result in a neutral transmittance or reflectance. The utilization of an energy absorbing film is preferred when the minimization of visible reflection is desired and a reduction of visible light transmittance is acceptable.

Absorbing films may also adversely impact the visible light transmittance to a level unacceptable for anti-reflective and solar control applications. For example, European Patent publication EP0780346 A1 discloses a method for producing tin oxide films doped with antimony oxide. The films are applied pyrolytically and result in a film having a molar ratio of tin to antimony of 1:0.2 to 1:0.5. The resulting films, when applied onto a neutral glass

substrate at a thickness of about 50 nm to about 1,500 nm, result in a visible light transmittance of less than 10 percent. The color of the films are generally a dark, gray-violet color. Thus, the low visible light transmittance and spectral properties renders such films undesirable for antireflective glass applications.

It would be advantageous to provide a coated glass article having a non-conductive, color neutral absorbing film that is capable of reducing the visible reflection from the glass while permitting a visible light transmittance of at least 30 percent. The film should also provide the desirable neutral color in both transmittance and reflectance.

It would be a further advantage to provide a non-conductive, color neutral absorbing film that may be applied pyrolytically onto a glass substrate. A pyrolytic film enables the deposition of the film on-line, for example, in a float glass production process.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a non-conductive, color neutral absorbing film suitable for use as a coating on glass. The film may be utilized for either solar control or anti-reflective glass articles. The film is an antimony/tin oxide alloy produced by combining an antimony source with conventional tin oxide deposition precursors. The amount of antimony present in the film is at least about five atomic percent. Due to considerations of cost and ease of manufacture, the amount of antimony present in the film is preferably from about five atomic percent to about ten atomic percent.

The antimony/tin oxide alloy is preferably applied pyrolytically, on-line onto a float glass ribbon. The

energy absorption properties of the film make it suitable for use with either solar control or anti-reflective glass articles.

5 In an anti-reflective glass, the energy absorbing film, having a refractive index of about 1.8 to about 2.6, may be utilized with a metal oxide, having a lower refractive index, to form a coated glass article. The high refractive index film is applied closest to the glass with the low refractive index film functioning as an outer
10 layer. The high/low stack reduces visible reflection to a level below five percent by the principle of optical interference. Additionally, the absorbing properties of the film enable a further reduction in visible reflection to a level below two percent. The thicknesses and optical
15 characteristics of the coating stack may be adjusted to achieve a broad range of specified transmittance values. However, in a preferred embodiment, the coated glass article has a visible light transmittance (Ill C) of at least 30%. The reflection and transmittance of visible
20 light are both aesthetically neutral in color.

It is an object of the present invention to provide an energy absorbing, neutral colored film for use as a coating on a glass substrate. The antimony/tin oxide alloy is an energy absorbing film that may be deposited onto a glass
25 substrate. The energy absorbing properties enable the use of the film in both anti-reflective and solar control coating stacks. Furthermore, the film exhibits a desirable neutral color in both transmittance and reflection.

It is a further object of the present invention to
30 provide an absorbing film that can be pyrolytically deposited onto a glass substrate. The antimony/tin oxide alloy of the present invention is suitable for use in conventional tin oxide deposition precursors. The pyrolytic

deposition enables the application of the film onto a float glass ribbon directly in the glass production process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5 In accordance with the present invention, it has been discovered that an antimony/tin oxide alloy film, having about five atomic percent to about ten atomic percent antimony, is suitable for use in a coated glass article. The film is an energy absorbing film that
10 exhibits a neutral color in visible light transmission and reflection. The coated glass article is especially suitable for use with anti-reflective glass articles utilized for computer displays or monitors. However, the coated glass article of the present invention may also be
15 utilized for other applications, such as architectural glazings and vehicle windows.

The glass substrates suitable for use in preparing the coated glass article according to the present invention may include any of the conventional clear glass compositions
20 known in the art. The preferred substrate is a clear float glass ribbon wherein the coating of the present invention, along with other optional coatings, is applied in the heated zone of the float glass process. However, other conventional processes for applying coatings on glass
25 substrates are suitable for use with the present inventive coating. Additionally, colored glass compositions may be utilized with the antimony/tin oxide alloy film of the present invention to achieve specific spectral and energy attenuation properties.

30 The antimony tin oxide coating of the present invention is a non-conductive, neutral colored film suitable for deposition onto a glass substrate. The film is a mixed antimony/tin oxide alloy produced by including an

amount of antimony of about five atomic percent to about ten atomic percent in a tin oxide film.

The antimony/tin oxide alloy films of the present invention enable the attenuation of light energy as it passes through the coated glass article. Energy applied to a coated glass article is either transmitted, reflected, or absorbed. The antimony/tin oxide alloy is an energy absorbing film which reduces the amount of light energy incident to the back glass-air interface and the glass film interface. Thus, the amount of reflected light is significantly reduced. The absorption of light results in the reduction of transmitted light through the glass. The absorption properties make the coating suitable for applications on glass for both anti-reflective coatings and solar control coatings.

The absorption properties of a coating or film are indicated by the extinction coefficient (k). Non-absorbing films have extinction coefficients of zero. Extinction coefficients for absorbing films are greater than 0.1, with higher values indicating greater energy absorption properties. The extinction coefficient for the antimony/tin oxide alloy coating is preferably about 0.1 to about 0.3.

Additionally, the antimony/tin oxide alloy coating of the present invention is a non-conductive film. Non-conductive films generally have a sheet resistance of greater than about 500 ohms per square. Coatings with sheet resistance value less than 500 ohms per square are considered conductive coatings.

Typically, absorbing materials are strongly colored. Therefore, when applied to films they enable either a neutral color in transmittance or reflectance, but generally can not be adjusted to accomplish both. The

present inventive coating exhibits an aesthetically neutral color in both transmittance and reflectance. The color is preferably indicated by CIELAB color scale values of a^* of about 6 to -9 and b^* of about 6 to about -9.

5 For a pyrolytic deposition, the antimony/tin oxide alloy is deposited onto the glass substrate by incorporating an antimony source with conventional tin oxide precursors. An example would include the use of antimony trichloride in an organic solvent, which is
10 vaporized and injected into a precursor gas stream containing dimethyltin dichloride, oxygen, and water in a helium carrier gas.

 The absorbing coating of the present invention can be utilized as an anti-reflective coating in conjunction with
15 other coatings to reduce the visible reflection by the principle of optical interference. Thus, the present inventive coating, having a refractive index of about 1.8 to about 2.6, may be utilized with a film having a low refractive index to achieve additional reductions in
20 visible reflection beyond those accomplished through absorption. An anti-reflective coating produced in accordance with the present invention may reduce visible reflections below 5%, and preferably below 2%. The reduction in visible reflection is achieved while
25 maintaining a visible light transmittance (Illuminant C two degree observer) of at least 30% or greater, preferably at least 40% or greater, and most preferably at least 50% or greater.

 For example, the present inventive coating may be
30 utilized with a film having a refractive index of about 1.45 to about 1.6, such as silicon oxide (SiO_2). A film stack on a clear substrate including a layer of antimony/tin oxide alloy followed by a layer of silicon

oxide is capable of achieving a visible reflectance below 2% and a neutral visible light transmittance (Ill C) of greater than 30%.

5 Additionally, a barrier layer may be applied to the glass prior to the application of the antimony/tin oxide alloy film. Barrier layers are utilized to prevent the migration of alkali metal ions from the glass substrate into the film. The migration of the alkali metal ions reduces the quality of the coated glass article and results
10 in the undesirable appearance of haze in the article. Barrier layers may include coatings of silicon oxide, silicon oxycarbide, or aluminum oxide. A barrier layer is generally applied at about 100-200 angstroms thick.

15 Alternatively, a conductive coating may also be applied in an anti-reflective coating stack in conjunction with the coating of the present invention. A conductive coating would enhance the utilization of the anti-reflective film by enabling the coated article to dissipate static charges that can build up on computer monitor
20 screens. The conductive coating is generally applied onto the antimony/tin oxide alloy prior to applying the metal oxide coating.

25 Conventional conductive coatings generally recognized within the art may be suitable for use in the present invention. Conductive metal oxide suitable for use with the invention include compounds selected from the group consisting of indium oxide doped with tin, indium oxide doped with fluorine, tin oxide doped with fluorine, tin oxide doped with antimony (less than 5, and typically 1 to
30 2 atomic weight percent antimony), zinc oxide doped with aluminum, zinc oxide doped with fluorine, zinc oxide doped with boron, and tungsten oxide doped with fluorine. The

conductive metal oxide is applied at a thickness of about 200 angstroms to about 5000 angstroms. Preferred conductive coatings include tin oxide doped with fluorine and indium oxide doped with tin.

5 In an anti-reflective coating, the thickness of each layer is a function of the desired component stack and the preferred reflectivity. Thus, the thickness of each layer is selected based upon the refractive indices of each film utilized in the stack and the preferred level of
10 reflectivity. One example of an anti-reflective coating would include the deposition of a barrier layer of about 100 angstroms of silicon oxide onto a 0.125 inch thick float glass ribbon. About 1200 angstroms of antimony/tin oxide is then applied over the barrier layer. A layer of
15 silicon oxide of about 700 angstroms thick is applied over the antimony/tin oxide alloy coating. The resulting article has a visible light transmittance (Ill C) of 52% and a visible reflection of about 1.7%.

In comparison to conventional anti-reflective
20 coatings, the present invention significantly reduces the visible reflection while also reducing the visible light transmittance. Conventional two layer anti-reflective coatings generally utilize a stack with each layer being $1/4 \lambda$ at a 550 nm design wavelength. The layers have
25 alternating high and low refractive indices. An example would include an undoped tin oxide layer of about 705 angstroms thick on a 0.125 inch glass substrate with a silicon oxide layer of about 948 angstroms thick applied over the tin oxide layer. The resulting coated articles
30 exhibit a visible light transmittance (Ill C) of 92.5% and a visible reflection of 5.5%. The present inventive coating has achieved a visible light transmittance (Ill C)

of 52% and a reflection of 1.7%. A clear glass substrate without coatings will typically reflect over 8% of the visible light.

5 The antimony/tin oxide alloy of the present invention may also be utilized with conventional multilayer anti-reflective stacks having greater than two anti-reflective films. The antimony/tin oxide alloy is suitable for use as a medium or high refractive index coating, depending upon the refractive index of other coatings used within the
10 multiple layer stack. For example, the antimony/tin oxide alloy of the present invention could be applied over a glass substrate with a titanium oxide coating applied over the antimony/tin oxide coating and a silicon oxide coating applied over the titanium oxide coating. The titanium
15 oxide coating would have a higher refractive index with the antimony/tin oxide alloy having an intermediate refractive index. The coated article would have a visible light transmittance (Ill C) of at least 30% and a visible reflectance, from the film side, of less than 1%.

20 The anti-reflective coated glass article is ideally suited for use in computer screens where a high contrast and neutral transmittance are desirable with little visible light reflection from the screen. Additionally, the antimony/tin oxide alloy film is suitable for use in
25 various architectural and automotive applications where high reflectivity is undesirable.

The following examples, which constitute the best mode presently contemplated by the inventors for practicing the present invention, are presented solely for the purpose of
30 further illustrating and disclosing the present invention, and is not to be construed as a limitation on, the invention:

Example 1

A float glass process was used to produce a clear float glass ribbon having a thickness of 0.125 inches. The glass ribbon was traveling at a line speed of about 433 inches per minute. A conventional coating apparatus is utilized in the float bath to apply a 203 angstrom coating of silicon oxide onto the surface of the float glass ribbon. The coating was applied by directing 12 standard liters per minute (slm) of ethylene, 5 slm of oxygen, and 2 slm of silane in 535 slm of a nitrogen carrier gas.

A 1156 angstrom coating of antimony/tin oxide alloy was applied onto the silicon oxide coating. Approximately, 17 pounds per hour of dimethyltin dichloride, 270 slm of oxygen, and 150 cc per minute of water were provided in a 200 slm helium carrier gas. About 70 cc per minute of antimony trichloride in solution was added to the precursor stream. The antimony trichloride solution contained about 30 mole percent antimony trichloride in ethyl acetate.

A 692 angstrom coating of silicon oxide was applied over the antimony/tin oxide alloy film. The outer layer was applied by directing a precursor gas mixture containing 42 slm of ethylene, 21 slm of oxygen, and 7 slm of silane in a 535 slm of a nitrogen carrier gas onto the coated glass ribbon.

The resulting coated glass article exhibited a 52.3% visible light transmittance (I_{ll} C) with a neutral color, in accordance with CIELAB Illuminant C 2 degree observer standard, as exhibited by an a* value of 2.1 and b* value of -1.5. The article had a visible light reflection of 1.7 and a neutral color as designated by an a* value of 3.8 and b* value of -4.1. The sheet resistance of the film was greater than 100,000 ohms per square. The antimony content

of the antimony/tin oxide alloy was about 11 atomic percent.

Example 2

5 A float glass process was used to produce a clear float glass ribbon having a thickness of 0.125 inches. The glass ribbon was traveling at a line speed of about 433 inches per minute. A conventional coating apparatus is
10 utilized in the float bath to apply a 220 angstrom coating of silicon oxide onto the surface of the float glass ribbon. The coating was applied by directing 12 standard liters per minute (slm) of ethylene, 8 slm of oxygen, and 2
15 slm of silane in 535 slm of a nitrogen carrier gas.

 A 1584 angstrom coating of antimony/tin oxide alloy
15 was applied onto the silicon oxide coating. Approximately, 19 pounds per hour of dimethyltin dichloride, 270 slm of oxygen, and 130 cc per minute of water were provided in a 150 slm helium carrier gas. About 35 cc per minute of
20 antimony trichloride in solution was added to the precursor stream. The antimony trichloride solution contained about 30 mole percent antimony trichloride in ethyl acetate.

 A 1561 angstrom coating of a fluorine doped tin oxide was applied onto the antimony/tin oxide alloy.
25 Approximately 6 pounds per hour of dimethyltin dichloride, 230 slm of oxygen, 8 slm of hydrofluoric acid, 9 slm of nitrogen and 150 cc per minute of water were provided in a 150 slm helium carrier gas.

 A 692 angstrom coating of silicon oxide was applied over the fluorine doped tin oxide coating. The outer layer
30 was applied by directing a precursor gas mixture containing 45 slm of ethylene, 30 slm of oxygen, and 7.5 slm of silane in a 535 slm of a nitrogen carrier gas onto the coated glass ribbon.

The resulting coated glass article exhibited a 37.2% visible light transmittance (Ill C) with a neutral color in accordance with CIELAB Illuminant C 2 degree observer standard of a* of 4.8 and b* of -6.5. The article had a visible light reflection of 1.4% and a neutral color as designated by an a* value of 0.0 and b* value of -7.3. The sheet resistance of the film was about 40 ohms per square after deleting the top silicon oxide layer with hydrofluoric acid. The antimony content of the antimony/tin oxide alloy was 6.2 atomic percent.

WHAT IS CLAIMED IS:

1. A coated glass article, comprising:

(a) a glass substrate,

(b) a coating of an antimony/tin oxide alloy applied onto said glass substrate, and

(c) a coating of a metal oxide applied over said coating of antimony/tin oxide alloy.

2. A glass article as recited in claim 1, wherein said antimony is present in the antimony/tin oxide alloy at levels of about 5 atomic percent or more.

3. A glass article as recited in claim 1, wherein said antimony is present in the antimony/tin oxide alloy at levels of about 5 atomic percent to about 10 atomic percent.

4. A glass article as recited in claim 1, wherein said coated article exhibits a reflectance of less than 5%.

5. A glass article as recited in claim 1, wherein said article has a visible light transmittance (Ill C) of about 30% or greater.

6. A glass article as recited in claim 1, wherein said coating of metal oxide has a refractive index of about 1.45 to about 1.6.

7. A glass article as recited in claim 6, wherein said metal oxide is SiO_2 .

8. A glass article as recited in claim 1, wherein said article exhibits a neutral color in transmission and reflectance as defined in the CIELAB system having an a^* value from about 6 to about -9 and a b^* value of about 6 to about -9.

9. A glass article as recited in claim 1, further comprising a barrier layer applied between said glass substrate and said coating of the antimony/tin oxide alloy.

10. A glass article as recited in claim 1, wherein said glass substrate is a float glass ribbon and said coatings are deposited pyrolytically onto said float glass ribbon.

11. A glass article as recited in claim 1, wherein said antimony/tin oxide alloy is applied at a thickness of about 500 angstroms to about 2500 angstroms, and said metal oxide is applied at a thickness of about 650 angstroms to about 1100 angstroms.

12. A glass article as recited in claim 1, further comprising a conductive metal oxide applied between said antimony/tin oxide alloy and said metal oxide coating.

13. A glass article as recited in claim 11, wherein said conductive metal oxide is selected from the group consisting of indium oxide doped with tin, indium oxide doped with fluorine, tin oxide doped with fluorine, tin oxide doped with antimony, zinc oxide doped with aluminum, zinc oxide doped with fluorine, zinc oxide doped with boron, and tungsten oxide doped with fluorine.

14. A glass article as recited in claim 11, wherein said conductive metal oxide is applied at a thickness of about 200 angstroms to about 5000 angstroms.

5 15. A glass article as recited in claim 1, wherein said antimony tin oxide alloy has an extinction coefficient of about 0.1 to about 0.3.

10 16. A glass article as recited in claim 1, wherein said antimony/tin oxide film have a sheet resistance of greater than 500 ohms per square.

17. An anti-reflective glass article, comprising:
15 (a) a glass substrate,
(b) a coating of an antimony/tin oxide alloy having a refractive index of about 1.8 to about 2.6 applied onto said glass substrate, and
(c) a coating of a metal oxide having a refractive index of about 1.45 to about 1.6 applied
20 onto said coating of antimony/tin oxide alloy, the coated article having a reflectance of less than 5%.

18. A glass article as recited in claim 17, wherein said glass article has a visible light transmittance (I_{ll}
25 C) of at least 30% or greater.

19. A glass article as recited in claim 17, wherein said glass article includes a metal oxide coating having a higher refractive index than said antimony/tin oxide alloy applied between said antimony/tin oxide alloy and said
30 coating of metal oxide.

20. A coated glass article, comprising:

(a) a glass substrate, and

(b) a coating including one of more layers of metal oxides or mixed metal oxides applied onto the glass substrate, at least one of the layers being an antimony/tin oxide alloy containing at least about 5 atomic percent antimony, the coated glass article having a visible light transmittance (Ill C) of 30% or greater.

21. A coated glass article as recited in claim 20, wherein said one or more layers of metal oxides or mixed metal oxides includes a conductive metal oxide.

INTERNATIONAL SEARCH REPORT

 International application No.
 PCT/US98/13531

A. CLASSIFICATION OF SUBJECT MATTER IPC(6) : B32B 9/04, 13/04, 17/06; G02B 5/22, 28 US CL : 359/359, 580, 586, 589; 428/216, 336, 432, 697, 699, 701, 702 According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 359/359, 580, 586, 589; 428/216, 336, 432, 697, 699, 701, 702 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X ---	US 5,362,552 A (AUSTIN) 08 November 1994, entire document.	1,4-21 -----		
Y		2-3		
X --	US 4,581,280 A (TAGUCHI et al) 08 April 1986, column 2, lines 18-37.	1,4-11,15-17,20 -----		
Y		2-3		
X --	US 4,504,109 A (TAGA et al) 12 March 1985, column 6, lines 12-32.	1, 4-21 -----		
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X	US 3,531,313 A (DATES) 29 September 1970, entire document.	1-6, 8, 10, 15, 16, 18, 20		
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Date of the actual completion of the international search 24 SEPTEMBER 1998		Date of mailing of the international search report 21 OCT 1998		
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,422,721 A (HAHN et al) 27 December 1983, claim 7.	1-8, 10, 11, 15-18, 20, 21

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